USDA Natural Resources Conservation Service

Ecological site F109XY009MO
Till Protected Backslope Forest

Accessed: 05/08/2024

General information

Approved. An approved ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model, enough information to identify the ecological site, and full documentation for all ecosystem states contained in the state and transition model.

Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 109X–Iowa and Missouri Heavy Till Plain

The Iowa and Missouri Heavy Till Plain (area outlined in red on the map) is an area of rolling hills interspersed with interfluve divides and alluvial valleys. Elevation ranges from about 660 feet along the lower reaches of rivers, to about 980 feet on stable interfluve summits in southern Iowa. Relief is about 80 to 160 feet between major streams and adjacent interfluve summits. Most of the till plain drains south to the Missouri River via the Grand and Chariton River systems, but the northeastern portion drains southeast to the Mississippi River. Loess caps the pre-Illinoisan aged till on interfluves, whereas the till is exposed on side slopes. Mississippian aged limestone and Pennsylvanian aged sandstone and shale crop out on lower slopes in some areas.

Classification relationships

Atlas of Missouri Ecoregions (Nigh & Schroeder, 2002):
This ecological site occurs in many Land Type Associations within the following Subsections:
Chariton River Hills
Claypan Till Plains
Mississippi River Hills
Wyaconda River Dissected Till Plains

Terrestrial Natural Community Type in Missouri (Nelson, 2010):
The reference state for this ecological site is most similar to a Dry-Mesic Loess/Glacial Till Forest.

Missouri Department of Conservation Forest and Woodland Communities (Missouri Department of Conservation, 2006):
The reference state for this ecological site is most similar to White Oak Loess/Glacial Till Forest.

National Vegetation Classification System Vegetation Association (NatureServe, 2010):
The reference state for this ecological site is within the North-Central Interior Dry-Mesic Oak Forest and Woodland (CES202.046), and is most similar to *Quercus alba* - *Quercus rubra* - Carya ovata Glaciated Forest (CEGL002068).

Ecological site concept

Till Protected Backslope Forests are within the green areas on the map. They occupy the northerly and easterly aspects of steep, dissected slopes, and are mapped in complex with the Till Exposed Backslope Woodland ecological site. These ecological sites occur primarily in the eastern and southeastern portion of the Till Plain. They are typically downslope from Loess Upland Woodland or Till Upland Woodland ecological sites, and generally occupy the mid to lowest portion of the hillslope. In a few places, a narrow band of Shale Protected Backslope ecological site is downslope. Soils are very deep, with dense till subsoils that are mainly clay loam. The reference plant community is forest dominated by white and northern red oaks, with a well-developed understory and a rich herbaceous ground flora.

Associated sites

F109XY003MO	**Loess Upland Woodland** Loess Upland Woodlands are often upslope from Till Protected Backslope Forests.
F109XY007MO	**Till Upland Woodland** Till Upland Woodlands are often upslope from Till Protected Backslope Forests.
F109XY013MO	**Interbedded Sedimentary Protected Backslope Forest** Interbedded Sedimentary Protected Backslope Forests are downslope from Till Protected Backslope Forests in some places.
F109XY022MO	**Till Exposed Backslope Woodland** Till Exposed Backslope Woodlands are mapped in complex with the Till Protected Backslope Forests, on southerly and westerly aspects.

Similar sites

F109XY007MO	**Till Upland Woodland** Till Upland Woodlands are on upper slopes and shoulders, with white oak and black oak dominating the canopy. Both the overstory and understory are more open that till protected backslope forests.
F109XY013MO	**Interbedded Sedimentary Protected Backslope Forest** Interbedded Sedimentary Protected Backslope Forests are downslope from Till Protected Backslope Forests in some places. Canopy composition is similar but these sites are somewhat less productive.

Table 1. Dominant plant species

Tree	(1) *Quercus alba* (2) *Quercus rubra*
Shrub	(1) *Ostrya virginiana* (2) *Aesculus glabra*
Herbaceous	(1) *Erigenia bulbosa* (2) *Podophyllum peltatum*

Physiographic features

This site is on upland backslopes, with slopes of 14 to 45 percent. It is on protected aspects (north, northeast, and east), which receive significantly less solar radiation than the exposed aspects. The site receives runoff from upslope summit and shoulder sites, and generates runoff to adjacent, downslope ecological sites. This site does not flood.

The adjacent figure (adapted from Festervand, 1994) shows the typical landscape position of this ecological site, and landscape relationships among the major ecological sites in the uplands and adjacent floodplains. The site is within the area labeled “3”, and is typically downslope from Till Upland Woodland ecological sites. In areas where the local drainageways have not dissected into the underlying residuum, Upland Drainagway or Floodplain ecological sites are directly downslope.

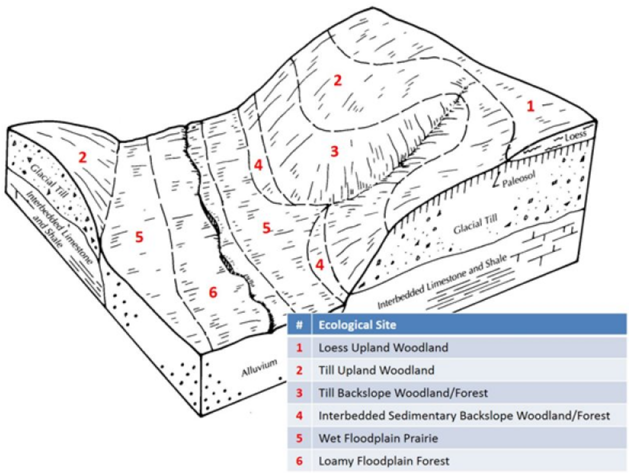


Figure 2. Landscape relationships for this ecological site

Table 2. Representative physiographic features

Landforms	(1) Hill
Flooding frequency	None
Ponding frequency	None
Slope	14–35%
Water table depth	61–183 cm
Aspect	N, NE, E

Climatic features

The Iowa and Missouri Heavy Till Plain MLRA has a continental type of climate marked by strong seasonality. In winter, dry-cold air masses, unchallenged by any topographic barriers, periodically swing south from the northern plains and Canada. If they invade reasonably humid air, snowfall and rainfall result. In summer, moist, warm air masses, equally unchallenged by topographic barriers, swing north from the Gulf of Mexico and can produce abundant amounts of rain, either by fronts or by convectional processes. In some summers, high pressure stagnates over the region, creating extended droughty periods. Spring and fall are transitional seasons when abrupt changes in temperature and precipitation may occur due to successive, fast-moving fronts separating contrasting air masses.

This MLRA experiences small regional differences in climates that grade inconspicuously into each other. The basic gradient for most climatic characteristics is along a line from north to south. Both mean annual temperature and precipitation exhibit fairly minor gradients along this line.

Mean January minimum temperature follows the north-to-south gradient. However, mean July maximum temperature shows hardly any geographic variation in the region. Mean July maximum temperatures have a range of only two to three degrees across the region.

Mean annual precipitation varies along the same gradient as temperature – lower annual precipitation in the north, higher in the south. Seasonality in precipitation is very pronounced due to strong continental influences. June precipitation, for example, averages four to five times greater than January precipitation.

During years when precipitation is normal, moisture is stored in the soil profile during the winter and early spring, when evaporation and transpiration are low. During the summer months the loss of water by evaporation and transpiration is high, and if rainfall fails to occur at frequent intervals, drought will result. Drought directly influences ecological communities by limiting water supplies, especially at times of high temperatures and high evaporation rates. Drought indirectly affects ecological communities by increasing plant and animal susceptibility to the probability and severity of fire. Frequent fires encourage the development of grass/forb dominated communities and understories.

Superimposed upon the basic MLRA climatic patterns are local topographic influences that create topoclimatic, or microclimatic variations. For example, air drainage at nighttime may produce temperatures several degrees lower in valley bottoms than on side slopes. At critical times during the year, this phenomenon may produce later spring or earlier fall freezes in valley bottoms. Slope orientation is an important topographic influence on climate. Summits and south-and-west-facing slopes are regularly warmer and drier, supporting more grass dominated communities than adjacent north- and-east-facing slopes that are cooler and moister that support more woody dominated communities. Finally, the climate within a canopied forest ecological site is measurably different from the climate of the more open grassland or savanna ecological sites.

Source: University of Missouri Climate Center - http://climate.missouri.edu/climate.php; Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin, United States

Department of Agriculture Handbook 296 - http://soils.usda.gov/survey/geography/mlra/

Table 3. Representative climatic features

Frost-free period (average)	156 days
Freeze-free period (average)	183 days
Precipitation total (average)	1,092 mm

Climate stations used

- (1) CHILLICOTHE 2S [USC00231580], Chillicothe, MO
- (2) KEOSAUQUA [USC00134389], Keosauqua, IA
- (3) OSCEOLA [USC00136316], Osceola, IA
- (4) UNIONVILLE [USC00238523], Unionville, MO

Influencing water features

The water features of this upland ecological site include evapotranspiration, surface runoff, and drainage. Each water balance component fluctuates to varying extents from year-to-year. Evapotranspiration remains the most constant. Precipitation and drainage are highly variable between years. Seasonal variability differs for each water component. Precipitation generally occurs as single day events. Evapotranspiration is lowest in the winter and peaks in the summer. Water stored as ice and snow decreases drainage and surface runoff rates throughout the winter and increases these fluxes in the spring. The surface runoff pulse is greatly influenced by extreme events. Conversion to cropland or other high intensities land uses tends to increase runoff, but also decreases evapotranspiration. Depending on the situation, this might increase groundwater discharge, and decrease baseflow in receiving streams.

Soil features

These soils have no major rooting restriction. The soils were formed under woodland vegetation, and have thin, light-colored surface horizons. Parent material is till. They have loam surface layers, with dense subsoils that are mainly clay loam. These soils are not affected by seasonal wetness. Soils in this protected aspect ecological site typically have thicker surface horizons relative to similar soils on exposed aspects (Steele, 2011). Soil series associated with this site include Brevator, Keswick, Lindley, and Winnegan.

The accompanying picture of the Winnegan series shows a thin surface horizon overlying the brown clayey till. Threads and filaments of calcium carbonate are below about 70 cm in this profile, and are typical in soils of this ecological site. Picture courtesy of Amber Steele; scale is in centimeters.

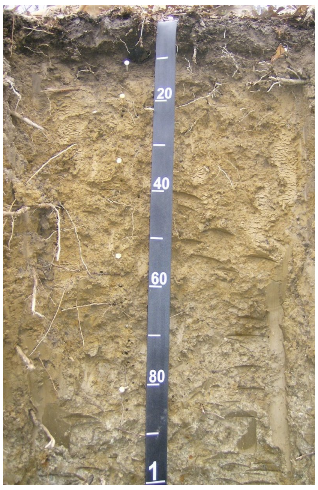


Figure 7. Winnegan series

Table 4. Representative soil features

Surface texture	(1) Loam (2) Clay loam (3) Silt loam
Family particle size	(1) Clayey
Drainage class	Moderately well drained to well drained
Permeability class	Slow
Soil depth	183 cm
Surface fragment cover <=3"	0–4%
Surface fragment cover >3"	0–1%
Available water capacity (0-101.6cm)	12.7–15.24 cm
Calcium carbonate equivalent (0-101.6cm)	0%
Electrical conductivity (0-101.6cm)	0–2 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	4.5–6.5
Subsurface fragment volume <=3" (Depth not specified)	1–10%
Subsurface fragment volume >3" (Depth not specified)	0–4%

Ecological dynamics

Information contained in this section was developed using historical data, professional experience, field reviews, and scientific studies. The information is representative of very complex vegetational communities. Not all scenarios or plants are included or discussed. Key indicator plants, animals and ecological processes are described to help guide land management decisions. Plant communities will differ across the MLRA because of the naturally occurring variability in weather, soils, and aspect. The Reference Plant Community is not necessarily the management goal. The biological processes on this site are complex. Therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are not intended to cover every situation or the full range of conditions, species, and responses for the site.

Till Protected Backslope Forests historically occurred in the most protected landscape positions on lower, steep slopes in the deeper valleys furthest from the prairie uplands. The reference plant community is a forest dominated by white (*Quercus alba*) and northern red oaks (*Quercus rubra*) and characterized by a tall (70 to 90 feet), closed canopy (80 to 100 percent) with a well-developed understory of white ash (*Fraxinus americana*), eastern hop hornbeam (*Ostrya virginiana*), Ohio buckeye (*Aesculus glabra*) and haws (Viburnum sp.), providing woody structural diversity not found in many adjacent woodland communities. The ground flora has many spring ephemerals and other shade loving herbaceous plant species (MDC, 2006; Nelson, 2010).

While the upland prairies and savannas in the area may have had a fire frequency of 1 to 3 years, Till Protected Backslope Forests would have burned less frequently (10 to 20 years) and with lower intensity (Frost 1996). In addition to periodic fire, these ecological sites were subjected to occasional disturbances from wind and ice, as well as grazing by native large herbivores. Wind and ice periodically opened the canopy up by knocking over trees or breaking substantial branches off canopy trees. Grazing by native large herbivores effectively kept understory conditions more open, creating conditions more favorable to oak reproduction.

Today, these ecological sites have been cleared and converted to pasture or have undergone repeated timber harvest and domestic grazing. Most existing forested ecological sites have a younger (50 to 80 years) canopy layer whose species composition and quality has been altered by timber harvesting practices. An increase in maple (Acer sp.) and hickories (Carya sp.)over historic conditions is not uncommon. In addition, in the absence of fire, the canopy, sub-canopy and understory layers are more fully developed. On protected slopes, the absence of periodic fire has allowed more shade tolerant tree species, such as sugar maple (*Acer saccharum*), white ash, and hickories to increase (Steele et al. 2013).

Uncontrolled domestic grazing has also impacted these communities, further diminishing the diversity of native plants and introducing species that are tolerant of grazing, such as buckbrush (*Symphoricarpos orbiculatus*), gooseberry (Ribes sp.), and Virginia creeper (*Parthenocissus quinquefolia*). Grazed sites also have a more open understory. In addition, soil compaction and soil erosion related to grazing can be a problem and lower site productivity.

These ecological sites are some of the most productive sites in the region. Oak regeneration is typically problematic. Sugar maple, red elm (*Ulmus rubra*), ironwood, hickories, pawpaw (*Asimina triloba*) and spicebush are often dominant competitors in the understory. Maintenance of the oak component will require disturbances that will encourage more sun adapted species and reduce shading effects. Single tree selection timber harvests are common in this region and often results in removal of the most productive trees (high grading) in the stand leading to poorer quality timber and a shift in species composition away from more valuable oak species. Better planned single tree selection or the creation of group openings can help regenerate and maintain more desirable oak species and increase vigor on the residual trees. Clearcutting also occurs and results in dense, even-aged stands dominated by oak. This may be most beneficial for existing stands whose composition has been highly altered by past management practices. However, without some thinning of the dense stands, the ground flora diversity can be shaded out and diversity of the stand may suffer.

Finally, on some forested sites in the northern part of the MLRA, invasive non-native species of earthworms (suborder Lumbricina) are beginning to have broad effects on the nutrient cycles in temperate forests. These earthworms increase the cycling and leaching of nutrients by breaking up decaying organic matter and spreading it into the soil. Temperate forests rely on thick layers of decaying organic matter for growth and nutrition. The invasive earthworm presence and activity is diminishing the diversity of native plants in these environments. This change in the plant diversity directly affects the other organisms of the environment and often leads to increased invasions of exotic species as well as overall forest decline. Restoration to a reference state under these conditions will be more difficult if not dramatically reduced or impossible (Hendrix et al. 2006; Nuzzo et al. 2009).

A State and Transition Diagram model follows. Detailed descriptions of each state, transition, plant community, and pathway follow the model. This model is based on available experimental research, field observations, professional consensus, and interpretations. It is likely to change as knowledge increases. The following diagram suggests some pathways that the vegetation on this site might take. There may be other states not shown on the diagram. This information is intended to show what might happen in a given set of circumstances. It does not mean that this would happen the same way in every instance. Local professional guidance should always be sought before pursuing a treatment scenario.

State and transition model

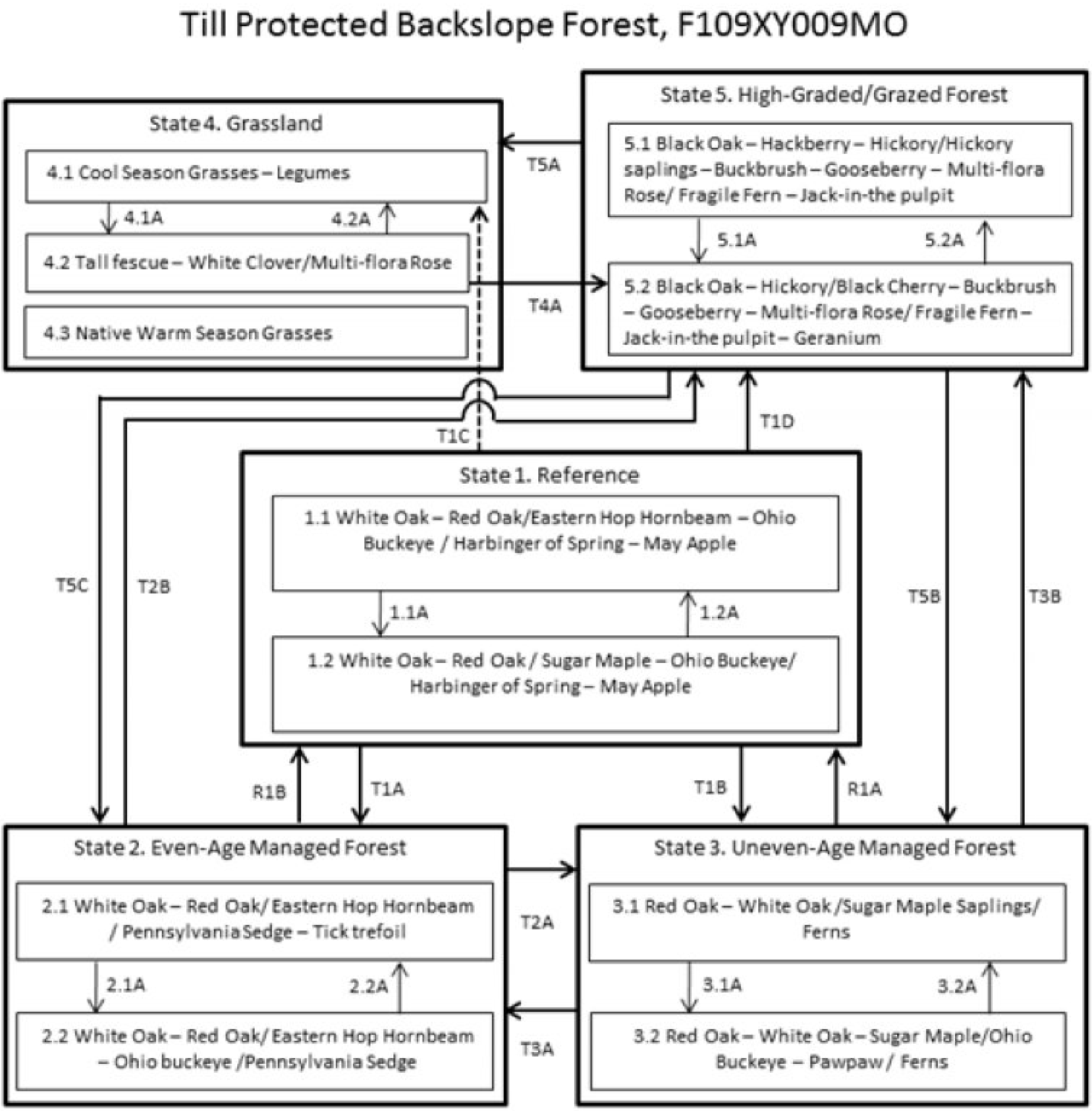


Figure 8. Till Protected Backslope Forest

Code	Event/Process/Activity
T1A	Controlled timber harvesting; even-aged forest management
T1B	Controlled timber harvesting; uneven-age forest management
T1C, T5A	Clearing; forage planting; grassland management
T1D, T2B, T3B	High-grade harvesting; uncontrolled grazing
T2A	Uneven-age forest management; thinning
T3A	Even-age forest management; thinning
T4A	Long-term succession (> 40 years); no grazing
T5B	Uneven-age management; thinning; no grazing
T5C	Even-age management; thinning; no grazing

Code	Event/Process/Activity
R1A, R1B	Extended rotations (limit harvesting to maintain at least 80 % canopy cover); long term succession (>20 years); selective thinning

Code	Event/Process/Activity
1.1A	Little to no site disturbance (20+ years)
1.2A	Periodic disturbance (fire, wind, ice) < 20 years
2.1A	Little to no site disturbance (20+ years)
2.2A	Controlled even-aged harvesting; forest stand improvement
3.1A	No harvesting activity (20+ years)
3.2A	Controlled uneven-aged harvesting; forest stand improvement
4.1A	Over grazing; no fertilization
4.2A	Brush management; grassland seeding; grassland management
5.1A	No harvesting activity (20+ years); periodic grazing
5.2A	High grade logging; uncontrolled grazing

Figure 9. Legend

State 1
Reference

The reference state was dominated by white oak associated with red oak and other mixed hardwoods. Maximum tree age was likely 150 to 300 years. Periodic disturbances from fire, wind or ice maintained the dominance of white oak by opening up the canopy and allowing more light for white oak reproduction. Long disturbance-free periods allowed an increase in more shade tolerant species such as northern red oak and sugar maple. Two community phases are recognized in this state, with shifts between phases based on disturbance frequency. The reference state can be found in scattered locations throughout the MLRA. Some sites have been converted to grassland (State 4). Others have been subject to repeated, high-graded timber harvests coupled with uncontrolled domestic livestock grazing (State 5). Fire suppression throughout the region has resulted in increased canopy density, which has affected the abundance and diversity of ground flora. Many reference sites have been effectively managed for timber harvesting, resulting in either even-age (State 2) or uneven-age (State 3) managed forests depending upon the removal intensity and the species selection.

Community 1.1
White Oak – Red Oak/Eastern Hop Hornbeam – Ohio Buckeye / Harbinger of Spring – May Apple

Figure 10. Reference state with overstory dominated by white oak and northern red oak - photo NRCS

Figure 11. White oak dominated canopy at Hungry Mother Conservation Area, Howard County, Missouri - photo from MDC

This community is one of the more productive upland forests in the MLRA. While the overstory is dominated by white oak and northern red oak, hickories can also be common. This forest community has a multi-tiered structure, and a canopy that is 75 to 100 feet tall with 80 to 100 percent closure. The sub-canopy and understory are well developed, with eastern hop hornbeam and Ohio buckeye (Iowa) as a dominant understory species. A moderate abundance of shade tolerant forest generalists, such as May apple, ferns, tick trefoils and white snakeroot cover the ground.

Forest overstory. White oak and red oak dominate with scattered hickory and black oak.

Forest understory. The understory layer is well-developed with white ash, eastern hop hornbeam, Ohio buckeye and haws. The ground flora has many spring ephemerals and other shade loving herbaceous plant species.

Table 5. Ground cover

Tree foliar cover	0.1-2.0%
Shrub/vine/liana foliar cover	0.01-0.99%
Grass/grasslike foliar cover	0.01-0.99%
Forb foliar cover	0.01-0.99%
Non-vascular plants	0%
Biological crusts	0%
Litter	75-100%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%

Bare ground	0.01-0.99%

Table 6. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	75-100%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0%

Table 7. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	0-0% N*
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	0-0% N*
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	0-0% N*
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	0-2% N*
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	0-1% N*
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	0-49 per hectare
Tree snag count** (hard***)	0-25 per hectare

*** Decomposition Classes: N - no or little integration with the soil surface; I - partial to nearly full integration with the soil surface.**

**** >10.16cm diameter at 1.3716m above ground and >1.8288m height--if less diameter OR height use applicable down wood type; for pinyon and juniper, use 0.3048m above ground.**

***** Hard - tree is dead with most or all of bark intact; Soft - most of bark has sloughed off.**

Table 8. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0-5%	0-25%	0-1%	2-10%
>0.15 <= 0.3	1-25%	1-10%	0-5%	2-25%
>0.3 <= 0.6	2-50%	1-25%	0-1%	0-10%
>0.6 <= 1.4	1-50%	0-2%	0%	0%
>1.4 <= 4	10-95%	0%	0%	0%
>4 <= 12	2-25%	0%	0%	0%
>12 <= 24	25-95%	0%	0%	0%
>24 <= 37	0-95%	0%	0%	0%
>37	0%	0%	0%	0%

Community 1.2
White Oak – Red Oak / Sugar Maple – Ohio Buckeye/ Harbinger of Spring – May Apple

Figure 12. White oak dominated reference site at Rebels Cove Conservation Area, Schuyler County, MO - photo from MDC

This phase is similar to community phase 1.1 but red oak and hickory densities are increasing due to longer periods of fire suppression (>20 years) and lack of natural disturbances such as ice and wind. Displacement of some less shade tolerant grasses and forbs such as nodding fescue and goldenrods along with lower densities of most species may be occurring due to shading and competition from the increased densities of oak, maple and hickory saplings in the mid-story.

Forest overstory. White oak and red oak dominate with scattered hickory and sugar maple.

Forest understory. This woodland community has a multi-tiered structure due to lack of disturbance activities. The understory layer is well-developed with maple, white ash, eastern hop hornbeam, Ohio buckeye and haws. The ground flora has many spring ephemerals and other shade loving herbaceous plant species.

Pathway 1.1A
Community 1.1 to 1.2

White Oak – Red Oak/Eastern Hop Hornbeam – Ohio Buckeye / Harbinger of Spring – May Apple

White Oak – Red Oak / Sugar Maple – Ohio Buckeye/ Harbinger of Spring – May Apple

Over time with the absence of disturbance, more shade tolerant species such as sugar maple (black maple in Iowa), bitternut hickory, white ash, basswood and others increase in importance and add structural diversity to the system. In addition, more shade-loving forest shrub (e.g., pawpaw) and herbaceous (e.g., bloodroot) species also increase

Pathway 1.2A
Community 1.2 to 1.1

White Oak – Red Oak / Sugar Maple – Ohio Buckeye/ Harbinger of Spring – May Apple

White Oak – Red Oak/Eastern Hop Hornbeam – Ohio Buckeye / Harbinger of Spring – May Apple

With periodic disturbances, such as fire, ice and wind that create canopy gaps, white oak and red oak are allowed to successfully reproduce and enter the canopy. Over time, these disturbance events result in a community phase transition back to the phase 1.1

State 2
Even-Age Managed Forest

This forest tends to be rather dense with an even-aged overstory and an under developed understory and ground flora. Thinning can increase overall tree vigor and improve understory diversity. Continual timber harvesting, depending on the practices used and age classes removed, will either maintain this state, or convert the site to uneven-age (State 3) forests. This state can be restored to a reference state by modifying or eliminating timber harvests, extending rotations, incorporating selective thinning, and re-introducing prescribed fire. (See Ecological Dynamics section for caution on sites with invasive non-native species of earthworms)

Community 2.1
White Oak – Red Oak/ Eastern Hop Hornbeam / Pennsylvania Sedge

Figure 13. Even-aged shelterwood harvest - photo from USDA Forest Service

This is an even-aged forest management phase. Logging activites are removing higher volumes of white oak causing a decrease in white oak in the canopy and an increase in red oak. Large group, shelterwood or clearcut harvests create a more uniform age class structure throughout the canopy layer while also opening up the understory and allowing more sunlight to reach the forest floor.

Forest overstory. Red oak and white oak are common overstory species along with an hickory. Canopy levels can approach 90 percent.

Forest understory. Rather dense ground cover dominated by forbs and shrubs especially after harvests.

Community 2.2
White Oak – Red Oak/ Eastern Hop Hornbeam – Ohio Buckeye / Pennsylvania Sedge

With cessation of harvesting and no other management inputs this community phase will slowly increase in more shade tolerant species such as hickories, white ash and maple. Over time white oak may become less dominant.

Forest overstory. White oak and red oak are common. Hickory species are increasing in the overstory.

Forest understory. In the long term absence of disturbance, oak and hickory saplings, black cherry and hornbeam encroach into the understory of these woodlands.

Pathway 2.1A
Community 2.1 to 2.2

This pathway results in a cessation or reduction of harvesting frequencies.

Pathway 2.2A
Community 2.2 to 2.1

Re-initiation of harvesting and other forest management activities will transition this community phase back to community phase 2.1.

State 3
Uneven-Age Managed Forest

An uneven-age managed forest can resemble the reference state. The primary difference is tree age, most being only 50 to 90 years old. Composition is also likely altered from the reference state depending on tree selection during harvests and disturbance activities. Without a regular 15 to 20 year harvest re-entry into these stands, they will slowly increase in more shade tolerant species such as sugar maple (black maple in Iowa) and white oak will become less dominant. This state can be restored to a reference state by modifying timber harvests, extending rotations, incorporating selective thinning, and re-introducing prescribed fire. (See Ecological Dynamics section for caution on sites with invasive non-native species of earthworms)

Community 3.1
Red Oak – White Oak /Sugar Maple Saplings/ Ferns

Figure 14. Un-evenaged selective harvesting - photo from Dwyer Forestry Consulting

This is an uneven-aged forest management phase. Selective logging activites are removing higher volumes of white oak causing a decrease in white oak in the canopy and an increase in red oak. Densities numbers, especially more shade tolerant species, are increasing at the lower size-class levels.

Forest overstory. Red oak and white oak dominate the overstory.

Forest understory. Maple, oak and hickory saplings, black cherry, Ohio buckeye and hop hornbeam are common understory species.

Community 3.2
Red Oak – White Oak – Sugar Maple/Ohio Buckeye – Pawpaw / Ferns

With cessation of harvesting and no other management inputs this community phase will slowly increase in more shade tolerant species such as hickories, white ash, red oak and maple in both the canopy layer and the understory.

Forest overstory. Red oak and white oak along with increasing densities of maple dominate the overstory.

Forest understory. In the long term absence of disturbance, maple, oak and hickory saplings, black cherry, Ohio buckeye and hop hornbeam encroach into the understory of these woodlands.

Pathway 3.1A
Community 3.1 to 3.2

This pathway results in a cessation or reduction of harvesting frequencies.

Pathway 3.2A
Community 3.2 to 3.1

Re-initiation of harvesting and other forest management activities will transition this community phase back to community phase 2.1.

State 4
Grassland

Conversion of forests to planted, non-native cool season grasses and legumes has been common. Without proper grassland management these ecological sites are challenging to maintain in a healthy, productive state. With over grazing and cessation of active pasture management, tall fescue, white clover and multi-flora rose will increase in density. In some instances, this state has been converted to native warm season grasses, primarily big bluestem, switchgrass, and Indian grass or pure stands of single species.

Community 4.1
Cool Season Grasses – Legumes

Figure 15. Well-managed cool season pasture near Lake Wapello State Park, Iowa - photo from MDC

This phase is a well managed grassland, composed of non-native cool season grasses and legumes. Grazing and haying is occurring. The effects of long-term liming on soil pH, and calcium and magnesium content, is most evident in this phase. Studies show that these soils have higher pH and higher base status in soil horizons as much as two feet below the surface, relative to poorly managed grassland (phase 4.2) and to woodland communities (where liming is not practiced).

Community 4.2
Tall fescue – White Clover/Multi-flora Rose

Figure 16. Cool season pasture showing weedy invasion due to poor management near Bloomfield, Iowa - photo from MDC

This phase is the result of poor grassland management. Over grazing and inadequate or no fertility application has allowed tall fescue, multi-flora rose, thistle and other weedy species to increase in cover and density reducing overall forage quality and site productivity. White clovers such as ladino and alsike will decrease or go away with no fertilization and overgrazing although Dutch white clover will leave last. Soil pH and bases such as calcium and magnesium are lower, relative to well-managed pastures (Phase 4.1).

Community 4.3
Native Warm Season Grasses

Figure 17. Native grasses and legumes on CRP land in southern Iowa - photo from NRCS

In some instances, this state has been converted to native warm season grasses, primarily big bluestem, switchgrass, and Indian grass or pure stands of single species. These sites are typically converted through a federal cost share program such as the Conservation Reserve Program (CRP) or the Environmental Quality Incentives Program (EQIP). Some sites are associated with an active rotational grazing system.

Pathway 4.1A
Community 4.1 to 4.2

Cool Season Grasses – Legumes

Tall fescue – White Clover/Multi-flora Rose

This pathway results from over grazing and cessation of active pasture management.

Pathway 4.2A
Community 4.2 to 4.1

Tall fescue – White Clover/Multi-flora Rose

Cool Season Grasses – Legumes

To return to Community Phase 4.1, requires brush management, grassland seeding, rotational grazing, and integrated pest management.

Conservation practices

Brush Management
Forage and Biomass Planting
Integrated Pest Management (IPM)
Prescribed Grazing

State 5
. High-Graded/Grazed Forest

Reference or managed forested states subjected to repeated, high-grading timber harvests and uncontrolled cattle grazing transition to this degraded state. This state exhibits an over-abundance of hickory and other less economically desirable tree species and weedy understory species such as buckbrush, gooseberry, poison ivy and multi-flora rose. The vegetation offers little nutritional value for cattle, and excessive livestock stocking damages tree boles, degrades understory species composition and results in soil compaction and accelerated erosion and runoff. Browsing by goats using good rotational management can open up the shrub layer, eliminate many of the weedy species and increase both native herbaceous vegetation and may induce regeneration of oak and hickory species. Cessation of active logging and exclusion of livestock from sites in this state will create an idle phase that experiences an increase in black cherry and Ohio buckeye in the understory layer. Transition back to either an even-age managed or uneven-age managed forest will required dynamic and sustained forest stand improvements, cessation of grazing, and selective thinning of overstory and understory canopies. (See Ecological Dynamics section for caution on sites with invasive non-native species of earthworms)

Community 5.1
Black Oak-Hickory/Hickory saplings -Gooseberry-Multiflora Rose/Fragile Fern-Jack in the pulpit

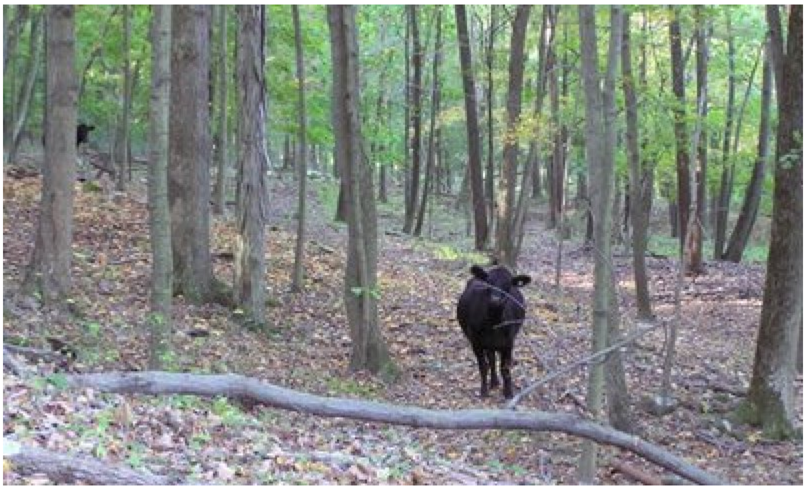


Figure 18. Actively grazed woodland creating an open understory - photo from NRCS

Due to high-grade logging and uncontrolled grazing, this community phase exhibits an over-abundance of hickory and other less economically desirable tree species and weedy understory species such as buckbrush, gooseberry, poison ivy and multi-flora rose. The understory vegetation offers little nutritional value for cattle, and excessive livestock stocking damages tree boles, degrades understory species composition and results in soil compaction and accelerated erosion and runoff.

Forest overstory. Canopy exhibits an over-abundance of hickory and other less economically desirable tree species such as black oak.

Forest understory. Over time, understory species such as buckbrush, gooseberry, poison ivy and multi-flora rose increase in density.

Community 5.2
Black Oak- Hickory/Black Cherry- Gooseberry / Fragile Fern – Jack in the pulpit-Geranium

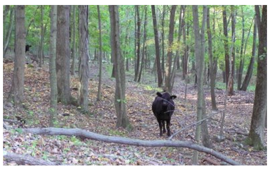
Figure 19. Lamson Woods State Preserve showing a high-graded formerly grazed woodland near Fairfield, Iowa - photo from MDC

Cessation of active logging and reduction in grazing intensity will create an idle phase that experiences an increase in black cherry and Ohio buckeye and weedy species such as buckbrush and gooseberry in the understory layer.

Forest overstory. Canopy exhibits an over-abundance of hickory and other less economically desirable tree species such as black oak.

Forest understory. Understory densities levels are increasing. Species such as black cherry, buckbrush, gooseberry, poison ivy and multi-flora rose are common.

Pathway 5.1A
Community 5.1 to 5.2

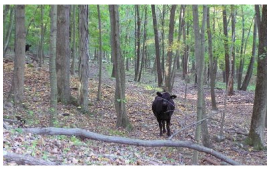


Black Oak-Hickory/Hickory saplings -Gooseberry-Multiflora Rose/Fragile Fern-Jack in the pulpit

Black Oak- Hickory/Black Cherry- Gooseberry / Fragile Fern – Jack in the pulpit-Geranium

This pathway results from cessation of active logging and periodic exclusion of livestock or reduction in grazing intensity.

Pathway 5.2A
Community 5.2 to 5.1



Black Oak- Hickory/Black Cherry- Gooseberry / Fragile Fern – Jack in the pulpit- Geranium

Black Oak-Hickory/Hickory saplings -Gooseberry- Multiflora Rose/Fragile Fern- Jack in the pulpit

This pathway results in a return to unrestricted logging activity and increased grazing intensities and frequencies.

Transition 1A
State 1 to 2

Fire suppression and even-aged forest timber management and harvesting will result in a transition to community phase 2.1.

Transition 1B
State 1 to 3

Fire suppression and uneven-aged forest timber management and harvesting will result in a transition to community phase 3.1.

Transition 1C
State 1 to 4

Clearing, pasture planting and grassland management will result in a transition to community phase 4.1.

Transition 1D
State 1 to 5

High grade logging and uncontrolled grazing will result in a transition to community phase 5.1.

Restoration pathway 1B
State 2 to 1

This state can be restored to a reference state by modifying or eliminating timber harvests, extending rotations, incorporating selective thinning and allowing long-term succession to occur.

Conservation practices

Forest Stand Improvement

Transition 2A
State 2 to 3

Thinning and selective harvesting will result in a transition to an unevenaged forest stand.

Transition 2B
State 2 to 5

High-grade harvesting and introduction of uncontrolled grazing will cause a transition to community phase 5.1

Restoration pathway 1A
State 3 to 1

This state can be restored to a reference state by modifying or eliminating timber harvests, extending rotations, incorporating selective thinning and allowing long-term succession to occur.

Transition 3A
State 3 to 2

Thinning and large group harvesting will result in a transition to an evenaged forest stand.

Transition 3B
State 3 to 5

High-grade harvesting and introduction of uncontrolled grazing will cause a transition to community phase 5.1

Transition 4A
State 4 to 5

This state will transition to a high-graded/grazed woodland idle phase with long term succession allowing woody species to become established and little to no grazing.

Transition 5C
State 5 to 2

This state will transition to a managed forest state with even-aged management, forest stand improvement, and suppression of grazing.

Transition 5B
State 5 to 3

This state will transition to a managed forest state with selective timber harvesting, forest stand improvement, and suppression of grazing.

Transition 5A
State 5 to 4

This state will transition to a grassland state with clearing, pasture planting, and grassland managment.

Additional community tables

Table 9. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
white oak	QUAL	*Quercus alba*	Native	18.3–30.5	10–95	17.8–63.5	–
northern red oak	QURU	*Quercus rubra*	Native	–	30–50	–	–
slippery elm	ULRU	*Ulmus rubra*	Native	–	10–20	–	–
sugar maple	ACSA3	*Acer saccharum*	Native	–	5–10	–	–
black oak	QUVE	*Quercus velutina*	Native	–	0–10	–	–
white ash	FRAM2	*Fraxinus americana*	Native	18.3–27.4	2–5	15.2–20.3	–
black maple	ACNI5	*Acer nigrum*	Native	–	0–5	–	–
shagbark hickory	CAOV2	*Carya ovata*	Native	18.3–30.5	1–2	12.7–17.8	–

Table 10. Community 1.1 forest understory composition

				Height	

Common Name	Symbol	Scientific Name	Nativity	(M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
Pennsylvania sedge	CAPE6	*Carex pensylvanica*	Native	0.1–0.2	0.1–5
oval-leaf sedge	CACE	*Carex cephalophora*	Native	0.1–0.3	0.1–1
hairy woodland brome	BRPU6	*Bromus pubescens*	Native	0.1–0.6	0.1–1
eastern woodland sedge	CABL	*Carex blanda*	Native	0.1–0.3	0–0.1
nodding fescue	FESU3	*Festuca subverticillata*	Native	0.1–0.6	0–0.1
Forb/Herb					
American ginseng	PAQU	*Panax quinquefolius*	Native	0.1–0.2	0.1–25
pointedleaf ticktrefoil	DEGL5	*Desmodium glutinosum*	Native	0.2–0.3	1–10
mayapple	POPE	*Podophyllum peltatum*	Native	–	1–5
toadshade	TRSE2	*Trillium sessile*	Native	–	1–5
lesser yellow lady's slipper	CYPAP4	*Cypripedium parviflorum var. parviflorum*	Native	–	0–5
harbinger of spring	ERBU	*Erigenia bulbosa*	Native	–	0.1–5
Virginia springbeauty	CLVI3	*Claytonia virginica*	Native	–	1–5
white fawnlily	ERAL9	*Erythronium albidum*	Native	–	1–5
clustered blacksnakeroot	SAOD	*Sanicula odorata*	Native	0.1–0.6	0.1–5
hepatica	HENO2	*Hepatica nobilis*	Native	–	1–2
Virginia snakeroot	ARSE3	*Aristolochia serpentaria*	Native	–	1–2
goldenseal	HYCA	*Hydrastis canadensis*	Native	–	1–2
largeflower bellwort	UVGR	*Uvularia grandiflora*	Native	–	1–2
American hogpeanut	AMBR2	*Amphicarpaea bracteata*	Native	0.1–0.2	1–2
nakedflower ticktrefoil	DENU4	*Desmodium nudiflorum*	Native	0.1–0.3	1–2
shining bedstraw	GACO3	*Galium concinnum*	Native	0.1–0.2	0.1–2
Carolina geranium	GECA5	*Geranium carolinianum*	Native	0.2–0.3	0.1–1
wild blue phlox	PHDI5	*Phlox divaricata*	Native	0.1–0.2	0.1–1
Clayton's sweetroot	OSCL	*Osmorhiza claytonii*	Native	0.1–0.2	0.1–1
feathery false lily of the valley	MARA7	*Maianthemum racemosum*	Native	0.1–0.3	0.1–1
Jack in the pulpit	ARTR	*Arisaema triphyllum*	Native	0.2–0.3	0.1–1
soft agrimony	AGPU	*Agrimonia pubescens*	Native	0.1–0.6	0.1–1
American lopseed	PHLE5	*Phryma leptostachya*	Native	0.1–0.2	0–1
Drummond's aster	SYDR	*Symphyotrichum drummondii*	Native	0.3–0.6	0.1–1
widowsfrill	SIST	*Silene stellata*	Native	0.2–0.3	0.1–1
goldenrod	SOLID	*Solidago*	Native	0.2–0.6	0.1–1
rue anemone	THTH2	*Thalictrum thalictroides*	Native	0.1–0.3	0.1–1
clasping Venus' looking-glass	TRPE4	*Triodanis perfoliata*	Native	0.3–0.6	0–0.1
jumpseed	POVI2	*Polygonum virginianum*	Native	0.1–0.6	0–0.1
fourleaf milkweed	ASQU	*Asclepias quadrifolia*	Native	0.1–0.3	0–0.1
Indianhemp	APCA	*Apocynum cannabinum*	Native	0.1–0.6	0–0.1
bristly buttercup	RAHI	*Ranunculus hispidus*	Native	0.1–0.3	0–0.1
bloodroot	SACA13	*Sanguinaria canadensis*	Native	0.1–0.2	0–0.1
white avens	GECA7	*Geum canadense*	Native	0.1–0.6	0–0.1

Fern/fern ally					
Christmas fern	POAC4	*Polystichum acrostichoides*	Native	–	1–5
northern maidenhair	ADPE	*Adiantum pedatum*	Native	0.2–0.3	0.1–1
lowland bladderfern	CYPR4	*Cystopteris protrusa*	Native	0.2–0.3	0.1–1
rattlesnake fern	BOVI	*Botrychium virginianum*	Native	0.1–0.2	0–0.1
Shrub/Subshrub					
American hazelnut	COAM3	*Corylus americana*	Native	–	1–3
common pricklyash	ZAAM	*Zanthoxylum americanum*	Native	0.2–2.4	1–2
blackhaw	VIPR	*Viburnum prunifolium*	Native	0.2–0.6	0.1–2
fragrant sumac	RHAR4	*Rhus aromatica*	Native	0.1–0.6	0.1–2
eastern poison ivy	TORA2	*Toxicodendron radicans*	Native	0.1–4.9	0.1–2
Allegheny blackberry	RUAL	*Rubus allegheniensis*	Native	0.2–0.6	1–2
coralberry	SYOR	*Symphoricarpos orbiculatus*	Native	0.2–0.6	0.1–1
Missouri gooseberry	RIMI	*Ribes missouriense*	Native	0.3–0.6	0.1–1
multiflora rose	ROMU	*Rosa multiflora*	Introduced	0.6–1.2	0–1
Tree					
hophornbeam	OSVI	*Ostrya virginiana*	Native	0.1–4.9	0.1–50
eastern redbud	CECA4	*Cercis canadensis*	Native	0.2–4.9	1–50
white ash	FRAM2	*Fraxinus americana*	Native	0.3–4.9	1–10
Ohio buckeye	AEGL	*Aesculus glabra*	Native	0.2–4.9	0.1–10
slippery elm	ULRU	*Ulmus rubra*	Native	0.1–0.6	0–10
common serviceberry	AMAR3	*Amelanchier arborea*	Native	0.1–0.6	1–5
pawpaw	ASTR	*Asimina triloba*	Native	–	1–5
white oak	QUAL	*Quercus alba*	Native	0.1–12.2	0.1–5
black oak	QUVE	*Quercus velutina*	Native	0.3–12.2	0.1–2
black hickory	CATE9	*Carya texana*	Native	0.2–2.4	1–2
bitternut hickory	CACO15	*Carya cordiformis*	Native	0.2–0.6	0.1–2
stiff dogwood	COFO	*Cornus foemina*	Native	0.2–0.3	0.1–1
black cherry	PRSE2	*Prunus serotina*	Native	0.1–0.6	0.1–1
common hoptree	PTTR	*Ptelea trifoliata*	Native	0.2–2.4	0.1–1
American basswood	TIAM	*Tilia americana*	Native	0.1–0.2	0–0.1
northern red oak	QURU	*Quercus rubra*	Native	0.1–2.4	0–0.1
eastern redcedar	JUVI	*Juniperus virginiana*	Native	0.1–4.9	0–0.1
Vine/Liana					
Virginia creeper	PAQU2	*Parthenocissus quinquefolia*	Native	0.1–0.3	5–10
frost grape	VIVU	*Vitis vulpina*	Native	0.1–24.4	0.1–2
summer grape	VIAE	*Vitis aestivalis*	Native	–	1–2
fourleaf yam	DIQU	*Dioscorea quaternata*	Native	0.1–0.6	0.1–1
American bittersweet	CESC	*Celastrus scandens*	Native	0.1–0.3	0–0.1

Table 11. Community 1.2 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
white oak	QUAL	*Quercus alba*	Native	–	10–70	–	–
northern red oak	QURU	*Quercus rubra*	Native	–	30–50	–	–
sugar maple	ACSA3	*Acer saccharum*	Native	–	5–20	–	–
white ash	FRAM2	*Fraxinus americana*	Native	–	5–10	–	–
black oak	QUVE	*Quercus velutina*	Native	–	0–10	–	–
black maple	ACNI5	*Acer nigrum*	Native	–	0–10	–	–

Table 12. Community 1.2 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
eastern woodland sedge	CABL	*Carex blanda*	Native	–	0–1
Pennsylvania sedge	CAPE6	*Carex pensylvanica*	Native	–	0–1
Forb/Herb					
pointedleaf ticktrefoil	DEGL5	*Desmodium glutinosum*	Native	–	0–5
nakedflower ticktrefoil	DENU4	*Desmodium nudiflorum*	Native	–	0–5
Carolina geranium	GECA5	*Geranium carolinianum*	Native	–	0–5
feathery false lily of the valley	MARA7	*Maianthemum racemosum*	Native	–	0–5
largeflower bellwort	UVGR	*Uvularia grandiflora*	Native	–	1–5
clustered blacksnakeroot	SAOD	*Sanicula odorata*	Native	–	0–5
Jack in the pulpit	ARTR	*Arisaema triphyllum*	Native	–	0–5
Clayton's sweetroot	OSCL	*Osmorhiza claytonii*	Native	–	0–5
wild blue phlox	PHDI5	*Phlox divaricata*	Native	–	0–5
jumpseed	POVI2	*Polygonum virginianum*	Native	–	0–5
bloodroot	SACA13	*Sanguinaria canadensis*	Native	–	1–5
smooth Solomon's seal	POBI2	*Polygonatum biflorum*	Native	–	1–2
American ginseng	PAQU	*Panax quinquefolius*	Native	–	0–1
rue anemone	THTH2	*Thalictrum thalictroides*	Native	–	0–1
Fern/fern ally					
rattlesnake fern	BOVI	*Botrychium virginianum*	Native	–	0–5
northern maidenhair	ADPE	*Adiantum pedatum*	Native	–	0–5
Shrub/Subshrub					
coralberry	SYOR	*Symphoricarpos orbiculatus*	Native	–	0–5
blackhaw	VIPR	*Viburnum prunifolium*	Native	–	0–5
Tree					
Ohio buckeye	AEGL	*Aesculus glabra*	Native	–	5–10
common serviceberry	AMAR3	*Amelanchier arborea*	Native	–	0–5
eastern redbud	CECA4	*Cercis canadensis*	Native	–	0–5
Vine/Liana					
Virginia creeper	PAQU2	*Parthenocissus quinquefolia*	Native	–	1–5
frost grape	VIVU	*Vitis vulpina*	Native	–	1–2
eastern poison ivy	TORA2	*Toxicodendron radicans*	Native	–	1–2

Animal community

This forest type contains high structural and compositional diversity important for a number of songbirds and amphibians. Wild turkey, white-tailed deer, and eastern gray squirrel depend on hard and soft mast food sources and are typical upland game species of this type.

Birds associated with late-successional, mature forests are Whip-poor-will, Great Crested Flycatcher, Ovenbird, Pileated Woodpecker, Yellow-billed Cuckoo, Summer Tanager, Wood Thrush, Red-eyed Vireo, Scarlet Tanager, Northern Parula (near streams), and Louisiana Waterthrush (near streams).

Reptiles and amphibians associated with these forests include: ringed salamander, spotted salamander, marbled salamander, central newt, long-tailed salamander, dark-sided salamander, southern red-backed salamander, small-mouthed salamander, three-toed box turtle, ground skink, western worm snake, western earth snake, American toad, and timber rattlesnake.

Hydrological functions

Most precipitation on sites in reference or well-managed timber states infiltrates the soil, and either recharges the local groundwater or moves slowly as lateral flow, surfacing in headwaters of ephemeral streams. The trees, the shrub and herbaceous understories, and the litter provide nearly 100 percent soil cover. Little or no surface runoff occurs on these sites, except for rare, high-intensity storms. These sites provide high yields of good-quality groundwater, which is released slowly into ephemeral streams over time.

In high graded woodland or poorly managed pasture states, soil compaction and reduced surface cover generally results in reduced infiltration and increased runoff. Groundwater recharge is reduced. Surface runoff results in soil erosion, which degrades water quality. The rapid release of runoff into ephemeral streams increases the risk of downstream flooding, and shortens the time when ephemeral streams are active.

Recreational uses

Hunting, bird watching, horseback riding, camping, and hiking are recreational uses of this ecological site. Reference and well managed sites provide good hunting for turkey, white-tailed deer, and squirrel. Recreational uses are reduced in the heavily grazed grassland state and high-graded woodland state. In many areas of this predominantly agricultural MLRA, these sites provide the only forests available for recreational use.

Wood products

This ecological site is productive. Timber harvesting can occur but care should be taken to maintain the integrity and character of the site.

Potential products include lumber, oak staves, pallet materials, and in some cases oak and walnut veneer (only on well managed or old growth sites).

Other information

Forest Management: Site index values range from 53 to 80 for oak. Timber management opportunities are excellent. This group responds well to management. A wide variety of management treatments are appropriate with this ecological site. Create group openings of at least 2 acres. Large clearcuts should be minimized if possible to reduce impacts on wildlife and aesthetics. Uneven-aged management using single tree selection or group selection cuttings of ½ to 1 acre are options that can be used if clear cutting is not desired or warranted. Uneven-aged management may slowly cause an increase in more shade tolerant species such as maple. Using prescribed fire as a management tool could have a negative impact on timber quality, may not be fitting, or should be used with caution on a particular site if timber management is the primary objective. Where possible, favor white oak, black walnut, black cherry, and northern red oak.

Table 13. Representative site productivity

Common Name	Symbol	Site Index Low	Site Index High	CMAI Low	CMAI High	Age Of CMAI	Site Index Curve Code	Site Index Curve Basis	Citation
northern red oak	*QURU*	55	80	34	50	50	820	–	
white oak	*QUAL*	53	72	34	48	50	820	–	

Inventory data references

The data contained in this document is derived from analysis of inventories, ecological interpretation from field evaluations, and various reference papers and books.

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Yatskievych, George A. 1999/2006/2013. Flora of Missouri. Missouri Dept. of Conservation in cooperation with Missouri Botanical Garden Press, Volumes 1-3.

Sampling methods (nested plots/transects/releve)

Reference Inventory Plots:
RECOCA02 Rebel’s Cove Conservation Area
DAHOCA01 Dark Hollow Natural Area
HNMOCA01 Hungry Mother Conservation Area

Level 2 and reconnaissance inventory:

Concept developed from Paul Nelson’s Terrestrial Natural Communities and other works, refined with Amber Steele’s thesis

2007: Kolaks/Meinert reconnaissance at Little Lost Creek CA and Rudolph Bennitt CA

2009/10: Steele/Steele/Kabrick reconnaissance for Till Backslope thesis study site selection (Atlanta CA, Hidden Hollow CA, Hungry Mother CA, Rebel’s Cove CA, Union Ridge CA, Sugar Creek CA, others)

2014: Reconnaissance in Iowa: (Lamson Woods, Lacey Keosaqua SP. others)

2014: Reconnaissance and Tier III plot establishment in Missouri (Dark Hollow CA, Mineral Hills CA, Union Ridge CA, Thousand Hills SP, Rudolph Bennitt CA)

Type locality

Location 1: Schuyler County, MO	
Township/Range/Section	T66N R16W S5
UTM zone	N
UTM northing	4489496
UTM easting	523448
Latitude	40° 33′ 21″
Longitude	92° 43′ 22″
General legal description	Plot RECOCA02 Rebel's Cove Conservation Area Winnegan pedon (from Steele, 2011)

Location 2: Sullivan County, MO	
Township/Range/Section	T46N R18W S28
UTM zone	N
UTM northing	4463746
UTM easting	506077
Latitude	40° 19′ 27″
Longitude	92° 55′ 42″
General legal description	Plot DAHOCA01 Dark Hollow Natural Area Winnegan pedon

Location 3: Howard County, MO

Township/Range/Section	T51N R15W S1
UTM zone	N
UTM northing	4343709
UTM easting	538887
Latitude	39° 14′ 30″
Longitude	92° 32′ 57″
General legal description	Plot HNMOCA01 Hungry Mother Conservation Area Winnegan pedon (from Steele, 2011)

Other references

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Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	
Contact for lead author	
Date	
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

2. **Presence of water flow patterns:**

3. **Number and height of erosional pedestals or terracettes:**

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

5. **Number of gullies and erosion associated with gullies:**

6. **Extent of wind scoured, blowouts and/or depositional areas:**

7. **Amount of litter movement (describe size and distance expected to travel):**

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

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12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

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14. **Average percent litter cover (%) and depth (in):**

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

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16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

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17. **Perennial plant reproductive capability:**
